CLAIMS

What is claimed is:

1. A method for controlling a seismic survey spread while conducting a seismic survey, the spread having a vessel, a plurality of spread control elements, a plurality of navigation nodes, and a plurality of sources and receivers, the method comprising the steps of:

collecting input data including

navigation data for the navigation nodes,

operating states from sensors associated with the spread control elements,

environmental data for the survey, and

survey design data,

estimating the positions of the sources and receivers using the navigation data, the operating states, and the environmental data;

determining optimum tracks for the sources and receivers using the estimated positions and a portion of the input data that includes at least the survey design data; and

calculating drive commands for at least two of the spread control elements using at least the determined optimum tracks.

2. The method of claim 1, wherein, the estimating, determining, and calculating steps are executed by a transform function.

3. The method of claim 2, wherein the positions are estimated according to a spread model within the transform function.

4. The method of claim 3, wherein the spread model calculates a first set of estimated positions using input that includes at least the operating states and the environmental data.

5. The method of claim 4, wherein the navigation data includes a second set of estimated positions, and the first and second set of estimated positions are combined with the transform function to produce the estimated source and receiver positions and predicted residuals.

6. The method of claim 5, wherein the predicted residuals are used to estimate a set of parameters that characterize the spread model.

7. The method of claim 6, wherein the spread model parameters are used to calibrate the spread model.

8. The method of claim 5, wherein the predicted residuals are used to estimate error states for sensors used to collect the environmental data.

9. The method of claim 2, wherein the optimum tracks are determined according to a weighting function within the transform function.

10. The method of claim 9, wherein the weighting function receives as inputs the survey design data and the estimated positions.

11. The method of claim 10, wherein the input from the survey design data includes performance specifications for the spread control elements.

12. The method of claim 8, wherein the weighting function applies relative weighting coefficients to the inputs for calculation of an optimum spread track by the transform function.

13. The method of claim 9, further comprising the step of validating the optimum tracks.

14. The method of claim 13, wherein the optimum tracks are input to the spread model for calculation of the drive commands.

15. The method of claim 1, further comprising the step of validating the calculated drive commands.

16. The method of claim 15, further comprising the step of delivering the validated drive commands to the spread control elements, whereby a desirable survey objective may be attained.

17. The method of claim 1, wherein each of the drive commands is used to control at least one of position, speed, and heading for one or more components of the spread.

18. The method of claim 1, wherein the drive commands include commands for controlling at least one of the vessel propeller, vessel thruster, spread component steering devices, and the vessel cable winches.

19. The method of claim 17, wherein the spread components include

one or more marine vessels, and

a plurality of components towed by at least one of the vessels, the towed components including cables, sources, sensors, and steering devices.

20. The method of claim 19, wherein the sensors include hydrophones.

21. The method of claim 19, wherein the spread components further include one or more vehicles not tethered to the one or more vessels.

22. The method of claim 1, wherein the sensors associated with the spread control elements include one or more sensor types of tension, water flow rate, inclination, orientation, acceleration, velocity, and position.

23. The method of claim 1, wherein the collected environmental data includes one or more data types of current, salinity, temperature, pressure, speed of sound, wave height, wave frequency, wind speed, and wind direction.

24. The method of claim 1, wherein the survey design data includes spread tracks, performance specifications, and survey objectives.

25. The method of claim 24, wherein the performance specifications include drag and maneuvering characteristics for the vessel, steerable cable devices, steerable source devices, and deflectors, drag characteristics for the towed cables, sources, and flotation devices, and winch operating characteristics.

26. The method of claim 1, wherein the survey design data includes one or more data types of area, depth, area rotation or shooting orientation, line coordinates, source and receiver positions, required coverage, local constraints, optimizing factors, and historical data.

27. The method of claim 1, wherein the collected input data includes one or more data types of pre-survey, operator input, present survey, near real-time, real-time survey, and simulated survey.

28. The method of claim 27, wherein the operator input data includes spread parameter settings and environmental data.

29. The method of claim 26, wherein the real-time survey data includes one or more data types of cable tension, water flow rate, inclination, orientation, acceleration, velocity, positioning, spread control element setting, environmental data, seismic signal and noise data, and operator input.

30. The method of claim 29, wherein the positioning data includes data from one or more sensors of the group consisting of GPS receivers, echo sounders, depth sensors, acoustic ranging systems, magnetic compasses, gyro compasses, radio-location systems, accelerometers, and inertial systems.

31. The method of claim 29, wherein the spread control element setting data includes one or more inputs of the group consisting of thruster setting, propeller pitch, propeller rotation speed, rudder angle, towing cable tension, winch position, deflector orientation, deflector angle of attack, deflector relative water speed, streamer steering device orientation, and streamer steering device wing angle of attack.

32. The method of claim 26, wherein the pre-survey data includes environmental sensor data.

33. The method of claim 26, wherein the simulated survey data includes one or more data types of simulated pre-survey, simulated operator input, simulated current survey, simulated near real-time, simulated real-time survey, and simulated environmental data.

34. The method of claim 26, wherein the collected input data further includes raw seismic sensor data.

35. The method of claim 34, further comprising the step of using the raw seismic sensor data to produce quality indicators for the estimated positions.

36. The method of claim 35, wherein the quality indicators include binning datasets, absolute noise data, signal-to-noise ratios, and seismic signal frequency content.

37. The method of claim 35, wherein the quality indicators are used to validate the real-time survey data, spread control operating states, and drive commands.

38. The method of claim 3, wherein the spread model is a hydrodynamic force model of the spread components.

39. The method of claim 38, wherein the force model includes marine current data.

40. The method of claim 3, wherein the spread model is a pure stochastic model of the spread components.

41. The method of claim 3, wherein the spread model employs one of the L-norm fitting criteria.

42. The method of claim 3, wherein the spread model is a neural network.

43. The method of claim 15, wherein the drive commands are validated according to geophysical and operational requirements.

44. The method of claim 43, wherein the geophysical requirements include achieving desired coverage of a subsurface area.

45. The method of claim 44, wherein the geophysical requirements include duplicating the seismic signal ray paths of a prior survey, and controlling the seismic sensor noise.

46. The method of claim 44, wherein the operational requirements include defining one or more safe passages for the spread through dangerous areas, determining an optimum time to perform one or more lines of the survey, and reducing non-production time.

47. The method of claim 1, wherein alternative drive commands are calculated for effecting a safe passage between two or more definable locations.

48. The method of claim 1, wherein the spread control elements include at least two of a rudder, a propeller, a thruster, one or more devices for steering towed cables and instruments, and one or more steerable flotation devices.

49. A system for controlling a seismic survey spread while conducting a seismic survey, the spread having a vessel, a plurality of spread control elements, a plurality of navigation nodes, and a plurality of sources and receivers, the system comprising:

a database for receiving input data including

navigation data for the navigation nodes,

operating states from sensors associated with the spread control elements,

environmental data for the survey, and

survey design data;

a computer-readable medium having computer-executable instructions for estimating the positions of the sources and receivers using the navigation data, the operating states, and the environmental data;

a computer-readable medium having computer-executable instructions for determining optimum tracks for the sources and receivers using the estimated positions and a portion of the input data that includes at least the survey design data; and

a computer-readable medium having computer-executable instructions for calculating drive commands for at least two of the spread control elements using at least the determined optimum tracks.

50. The system of claim 47, wherein the position-estimating instructions, the optimum track-determining instructions, and the drive command-calculating instructions are contained in a common computer-readable medium.

51. The system of claim 47, further comprising a computer-readable medium having computer-executable instructions for validating the calculated drive commands.

52. The system of claim 49, further comprising a network for delivering the validated drive commands to the spread control elements, whereby a desirable survey objective may be attained.